Small Farmers and Big Retail: Trade-offs of Supplying Supermarkets in Nicaragua

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Summary. — In Nicaragua and elsewhere in Central America, small-scale farmers are weighing the risks of entering into contracts with supermarket chains. We use unique data from cooperatives supplying supermarkets to study the effect of supply agreements on producers’ mean output prices and price stability. We find that prices paid by the domestic retail chain approximate the traditional market in mean and variance while mean prices paid by Walmart are significantly lower than the traditional market. However, the Walmart contract is found to systematically reduce price volatility. We find some evidence, however, that farmers may be paying too much for this contractual insurance against price variation.

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Key words — small farmers, supermarkets, contracts, Walmart, Latin America, Nicaragua

1. INTRODUCTION

Supply relationships between supermarket chains and small farmers in the developing world represent a key intersection of current critical dimensions of economic theory and policy: participation of the rural poor in regional and global markets; possibilities for rural entrepreneurship; and contracts between small growers and large buyers to resolve idiosyncratic market failures.

This paper uses data from Nicaraguan supermarket contracts as well as traditional markets, to analyze market relationships emerging between farmers and supermarkets, and compare them with payoffs farmers receive from participation in traditional markets. The contracts are negotiated by three Nicaraguan farmer-cooperatives and vary both over supermarket chains and over time.

Using these data we establish for the first time in the developing country context, how supply agreements impact farmers’ output price distributions compared with the traditional market and how supermarket-farmer contract terms change over time. The resulting analysis offers a new perspective on potential payoffs for farmers of participation in supermarket supply chains.

This paper focuses on the analysis of the supermarket price distributions (compared with traditional market price distributions). Where working assumptions about the nature of the average farm in the cooperative are needed, we draw from stylized facts about farmer behavior from Michelson (2010), which analyzes household behavior using farm data in the same study areas as the present paper. These two treatments are complementary, as the present paper builds on the existing literature and focuses on price formation with respect to contracts and long price series, while Michelson (2010) focuses on cross sectional household characteristics and responses.

Past research has focused on understanding whether and why supermarkets source from small farmers and on establishing welfare impacts of supermarket supply relationships on small farmers. Considerable research has anticipated (Barrett & Reardon, 2000; Blandon, Henson, & Islam, 2009; Gibbon, 2003; Key & Runsten, 1999; Kirsten & Sartorius, 2002) and identified (Boselie, Henson, & Weatherspoon, 2003; Dolan & Humphrey, 2000; Reardon, Timmer, Barrett, & Berdegue, 2003) the exclusion of small farmers from supermarket supply chains. Other findings suggest that small farmers are included (Maertens & Swinnen, 2009) or find that inclusion is confined

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to those small farmers who are relatively WELL-EQUIPPED with nonland capital such as irrigation (Hernández, Reardon, & Berdegué, 2007), or who gain access through established producer associations (Balsevich, Berdegué, & Reardon, 2006). Most of the research analyzing participation in supermarket supply chains also considers the welfare effect of that participation.

However, there has been a relative lack as yet of rigorous analysis of a fundamental question: the ways that supermarket supply relationships affect participants’ mean output prices and price stability. Typically, the approach has been to compare average returns per kilogram, controlling for quality, between farmers supplying to supermarkets and those not. The extant literature does not often empirically test for increased farmer mean profit or decreased marketing risk under contractual relationship with a supermarket (a gap in the literature noted by Boselie et al., 2003; Kirsten & Sartorius, 2002; Neven & Reardon, 2008; Swinnen, 2007; Swinnen & Maertens, 2007).

Three important gaps thus exist in the literature. First, no paper has addressed whether the terms of exchange for small farmers—both level and variance—are better or worse with modern versus traditional retail. Second, while there has been measurement of the average payoff over channels using farm data, the robustness of these findings has not been validated over time, over contract types, or over chains (and thus types of modern retailers). At most, prior literature has compared average prices for a given year over market channels and, to our knowledge, no research has compared pricing behavior of a domestic chain with a multinational retailer. Finally, analyses have been confined to study of the average payoff, with little attention to variability. A number of works have posited that supermarkets reduce output price variability but have lacked data to test whether variability is reduced and by how much.

The contribution of this paper is to examine, for the first time in the literature, the average payoff and payoff variability of supermarket channels compared with those of the traditional market channel using high-frequency time series data of prices paid by supermarkets to farmers in small farmer cooperatives. We find that prices paid by La Colonia, the domestic chain, approximate the traditional market in mean and variance—prices paid to suppliers of Walmart supermarkets are significantly lower than the traditional market. Instead of a higher mean price, we find that Walmart supply agreements represent significant reductions in price risk to farmers over the traditional market. Deriving farmers’ implied relative risk aversion from these contracts, we find evidence that farmers may be paying too much for this implicit insurance against price variation of the traditional market.

This study uses data collected from two primary sources. First, we transcribed from three farmer cooperatives detailed records of the historical semi-weekly prices paid to them by supermarkets. We observe the full set of prices paid by Walmart and La Colonia to their primary supply cooperatives between April 2005 and May 2008. While the data are fully representative of prices transacted for these primary supermarket supply cooperatives in Nicaragua during this period, the sample may not be representative of all transactions between supermarkets and small holders nationwide in Nicaragua. The data cover three small cooperatives and five horticulture products with a mean of 145 observations per cooperative-product pair. Second, we use historical (January 2001–June 2008) traditional market weekly price data from the Nicaraguan Ministry of Agriculture and Forestry (MAGFOR). Because the focus of this work is comparison of the price distributions, and because the cooperative price is a blanket price paid to all farmers in the cooperative rather than prices negotiated by individual farmers, there is no micro-level household analysis of participants. Related issues such as farm cost differences across channels and farmer marketing portfolio choices are considered elsewhere, such as in the work of Michelson (2010).

Because our analysis compares crop prices across marketing channels, we have given careful consideration to possible differences in produce quality between markets. Based on interviews with supermarket buyers and traditional market wholesalers as well as considerable time spent observing transactions in wholesale markets and supermarkets, we have found that supermarkets in Nicaragua purchase the portion of farmers’ horticultural production that is the highest quality. Michelson (2010) finds, for example, that over farmers selling to supermarkets, the mean supermarket purchase share of farmers’ total production is close to 70%. The latter share is carefully selected: for example, Walmart follows a tightly-guarded manual of product-specific quality standards, codifying required attributes such as variety, size, coloration, cleanliness, damage, and weight. The domestic chain follows a similar quality selection process. In contrast, traditional market wholesalers purchase nearly 100% of a seller’s production, buying all size grades, discarding only damaged or extremely small produce.

Because supermarkets purchase less than 100% of the production of farmers from whom they buy, and because that share is carefully edited to meet chain-specific standards, our analysis assumes that mean product quality in the supermarket channel is at least as high as the traditional channel. That we compare a product in the supermarket chain with quality at least as high as the traditional market, makes even stronger our finding that mean prices paid by Walmart are not significantly higher than in the traditional market.

The next section provides context: critical features of the Nicaraguan traditional and modern horticulture markets, the population of horticulture producers, and the operations of the two primary supermarket chains operating in the country. The third section analyzes the mean and variance in output prices, comparing supply agreements between farmers and supermarkets in Nicaragua with prices in the traditional wholesale market. A fourth section derives coefficients of farmer relative risk aversion to evaluate the mean/variance trade-off for a farmers’ cooperation in the Walmart supply chain. The final section concludes.

2. TRADITIONAL AND MODERN HORTICULTURE SECTORS IN NICARAGUA: CONTEXT

Nicaragua’s population of horticulture producers constitutes a tiny share of its total farmers.

According to the country’s 2001 agricultural census, while 76% of landholding farmers grew basic grains (mainly maize and sorghum) and beans; only 2.14% cultivated tomatoes, 1.23% green peppers, and 0.25% cabbage (MAGFOR, 2001). Statistics on irrigation suggest the existence of dual production structures in Nicaragua’s tiny horticulture sector; approximately one-third of 2001 horticulturalists were equipped with irrigation. The population of irrigated horticulturists in the 2001 agricultural census was nearly evenly split between large growers with more than seven hectares and small and medium growers with less than seven hectares.

This production dualism defined by irrigation is critical to the producers’ experience in seasonally volatile horticulture output markets. Rainfed Nicaraguan horticulture farmers generally produce one or two seasons of crops each year and sell their harvest in a regional spot market or to a buyer at the farmgate.
Nicaraguan small farmers without irrigation describe highly volatile fresh fruit and vegetable prices driven primarily by supply swings in the market. The farmer without irrigation, cold storage, or means to move perishable produce quickly to another zone must sell when there is a local glut and suffer the price drop. Thus, farmers without irrigation are likely to be more concerned about price variability than those with irrigation who can sell in times of high prices and benefit from price variation.

Dualism in the Nicaraguan horticulture production sector therefore suggests a potential tension in supermarket contract adoption. While the supermarket is likely to prefer irrigated farmers who can offer the retailer steady supply throughout the year, those with irrigation and capacity have less incentive to adopt the contract given that they are already “playing the market,” riding the ups and downs of the output price. Conversely, rainfed horticulture farmers struggling to manage high price volatility will have more incentive to adopt the supply contract but are likely to be hindered by a lack of year-round productive capacity.

A third-party program funded by the United States Agency for International Development (USAID) emerged in Nicaragua to equip small farmers with the irrigation systems and liquidity to permit an intensive farming schedule and to begin to resolve this contracting asymmetry. In June 2006 USAID contracted with four multinational NGOs to begin working with farmers on a three-year, large project (USAID, 2006) designed to meet the supply needs of supermarkets. Supermarkets in Nicaragua function as buyers only. They currently offer no credit or technical assistance to cooperatives. Through the USAID program, NGOs resolve idiosyncratic market failures of small farmers by assisting with credit, irrigation, and technical assistance. The NGOs decrease the transaction costs of both farmers and supermarkets by managing contract negotiation between the cooperative and supermarket as well as the aggregating, selection, and cleaning of produce to meet supermarket quality standards for twice-weekly transactions. The cooperative itself as an organization acts as an intermediary (as it signs the contract) between the supermarket and the farmer and aggregates farmers’ produce. Therefore the farmer’s supply relationship with the supermarket is supplemented by NGO as well as cooperative services.

Members of the three cooperatives whose price data we analyze were largely without irrigation before becoming suppliers. Table 1 disaggregates supplier farmers according to their 2001 landholdings and irrigation in the year before beginning their relationship with the NGO and the supermarket; mostly small farmers (77.8%) and mostly without irrigation (88.9%). NGOs thus chose villages where most farmers did not have irrigation. Yet the NGOs were aware that the supermarket chains prefer farmers with irrigation so that supply can be continuous over the year. Hence, the NGOs provided irrigation to the rainfed farmers so that they could participate in the contract with the supermarkets.

Our participant price data are from cooperatives assisted and at least partially financed by these NGOs. Over 2005–08, the NGOs were significantly involved in the cooperatives’ contract negotiations with supermarket chains. The NGOs reported that they communicated with supermarket buyers several times a week by cell phone to update order quantities and used contacts in the central markets to check the spot market prices. Moreover, the cooperatives sell in bulk via one group transaction to the supermarkets, reducing the buyer’s coordination costs, quality assessment costs, and transport costs. Because of these advantages for the supermarket, we posit that these NGO-assisted cooperative suppliers are positioned to negotiate relatively a high price with supermarkets compared with either small farmers working independently or small farmers working in cooperatives unassisted by NGOs. Our finding that the supermarket prices paid to NGO-assisted farmers do not systematically dominate the traditional market therefore suggests that unassisted small farmers are unlikely to fare better in supermarket relationships.

### 3. SMALL FARMER OUTCOMES: PRICE MEAN AND VOLATILITY

Taking the contract choice as given, in this section we use data from traditional markets and producer cooperatives to study how supply agreements between small farmers and supermarkets affect mean price and price stability. The prices from the supermarkets are both contract-specific and transaction-specific. Walmart signs contracts semi-annually with the cooperatives that include quality standards and specifications regarding the volume and timing of deliveries as well as the negotiated minimum and maximum prices the supermarket will pay.

(a) **Construction of comparison price series**

Our analysis uses per kilogram farmgate prices to compare the traditional and supermarket channels. Transaction sites...
vary by supply chain, so we equalize prices at the farmgate by subtracting transport costs to comparison markets. We describe briefly how the farmgate price series are constructed.

Because Walmart picks up products sourced from farmers in farmer communities well outside the capital city, we equalize transport costs between the Walmart farmgate prices and the Managua-sited transactions of La Colonia and the traditional market. We subtract cooperative-specific transport costs from the La Colonia price and the Managua traditional market price. We have comprehensive estimates for transportation costs that include the per mile cost of the truck, gasoline, and driver, generated using the Sébaco cooperative’s round-trip cost for the trip between Managua and Sébaco (50 miles one-way) and the truck’s capacity.

The Sébaco cooperative rents the truck from a member of the cooperative and pays the cost of the gasoline and the driver. All three cooperatives are located on a good road network, at varying distances from Managua. We apply the per-pound/per-mile transport cost to each cooperative’s mileage from Managua to generate cooperative-specific transport costs. The cooperatives are at varying distances from Managua: Tomatoya, 70 miles, and Ocotal, 103 miles. Once we equalize transport costs, we can compare farmgate prices among the traditional market and La Colonia in Managua and Walmart’s transactions at farmgate. Unless otherwise noted, prices are compared between supermarket and traditional market channels over equivalent time periods. That is, if a contract relationship between a supermarket and a cooperative lasted between April 2005 and November 2006, the comparison traditional market price series is considered for the same period. Also unless otherwise specified, all prices in the paper have been adjusted to July 1999 Cordobas. One January 2008 US$ = 14.53 July 1999 Cordobas (SC). Computed farmgate prices are gross per kilogram.

(i) Nontransport related transactions costs

We have observed that farmers selling to supermarkets generally incur the standard transactions costs of the traditional market (loading, transport, unloading) in addition to the costs of sorting, grading, cleaning, and packing produce for learning, and to meet supermarkets’ specific quality criteria. Based on interviews with key informants we therefore hypothesize that production and transactions costs are higher in the supermarket channel. Moreover, as discussed in the introduction, while farmers can sell all of their output in traditional markets with minimal loss due to quality grading, Michelson (2010) notes for the study area farmers that farmers supplying supermarkets sell approximately 70% of their production to the supermarkets and sell the rest in nonsupermarket channels. Because the supermarket does not purchase all of a farmers’ output, supermarket channel supplier farmers sell not just to supermarkets but also to traditional markets, and thus face two different sets of transactions costs, depending on the channel.

Given that farmers’ production and marketing costs are likely to increase with participation in the supermarket channel, and given that farmers are aware of this, farmers are expected to try to cover the extra costs (over the traditional channel) with higher prices from supermarkets. We will show, however, that on average the prices in the supermarket channel are in fact not higher, so the farmers are not fully compensated for the difference in production and transport costs between the supermarket channel and the traditional channel. We will show that this paradox can be explained by the fact that price risk is lower in the supermarket channel.

(b) Supermarkets do not higher mean prices than the traditional channel

Because supermarkets purchase the high quality share of the farmers’ produce and require post-harvest processing beyond the demands of the traditional market, we expect farmers selling to supermarkets to receive higher mean output prices for their produce. We can test whether mean prices in the supermarket channel are significantly higher than in the traditional market by matching data collected from cooperatives with traditional market prices over corresponding periods. Because the two retail chains’ distinct procurement strategies have important implications for the analysis, we evaluate the chains’ contract prices in turn.

(i) Walmart

The timing of the contract observations is valuable to understand the sequence of Walmart supply agreements. We observe two epochs of Walmart supplier relations: that with Sébaco cooperative is an example of first-generation Walmart supply agreements, and that with Ocotal, a second-generation contract. The Sébaco cooperative sold to Walmart between April 2005 and November 2006. In November 2006 the cooperative’s relationship with Walmart was terminated and the cooperative began to supply La Colonia, providing an observation of a cooperative that operated in both supermarket channels. The Ocotal cooperative contracted with Walmart as the Sébaco cooperative left the supermarket in mid-2006. We will refer to the Ocotal relationship as a second generation Walmart contract.

In the top half of Table 2 we compare mean per kg farmgate prices between Walmart and the traditional market using a standard t-test to test for equivalence in means between the traditional market and supermarket farmgate price distributions. We find that, for both first and second generation contracts, mean prices for both salad tomatoes and roma tomatoes are statistically significantly lower selling to Walmart than the traditional channel. The gap in mean prices across the channels is also economically significant; the difference between Walmart and the traditional market price (as a percentage of the Walmart price) is between 34% and 54%.

(ii) La Colonia

In the bottom half of Table 2 we compare the La Colonia price series against their traditional market counterparts for the Sébaco and Tomatoya cooperatives. We find that La Colonia’s mean farmgate prices compare somewhat more favorably to the traditional market than Walmart. La Colonia represents a mix of both higher and lower mean farmgate prices than the traditional market. Over the specified time periods we find: La Colonia’s mean lettuce farmgate prices are significantly lower than those in the traditional market; La Colonia’s mean salad tomato and cabbage prices are significantly higher than the traditional market channel; and we fail to reject the hypothesis of the equivalence of mean farmgate prices between the La Colonia channel and the traditional market for roma tomato and small green peppers.

Results in Table 2 demonstrate two general results. First, prices in the supermarket supply channel are not always significantly higher than the traditional market. Second, La Colonia offers a mean price that is a much closer approximation to the traditional market while Walmart compares relatively poorly with the traditional market, paying suppliers significantly below parity.

These results are even more surprising given that prices in Table 2 are gross of post-harvest production costs specific to
the supermarket chain including cleaning, selecting, and packing.

For example, Sébaco cooperative farmers who sell to La Colonia contribute 3% of their sales proceeds for administrative services, and weekly pay a team of 10 women who select and clean produce for $C 100 a piece (2008 Cordobas). So the net supermarket farmgate price is even lower than reported above. Again, because of the post-harvest processing and selection costs incurred by the farmer cooperative we would expect a significantly higher mean price. Yet this is not what we find. A low mean price in the supermarket channel may result from asymmetrical bargaining power between the supermarket and the cooperative. Unfortunately, there are insufficient data on supermarket costs and cooperative sales in traditional markets to permit an analysis of this point.

Our analysis of supermarkets’ relative mean price raises two interesting questions. Why might farmers accept a low price for a quality product if a higher traditional market price were available? And why are mean farmgate prices with Walmart systematically lower than the traditional market relative to La Colonia?

One explanation for the differences between the chains in Table 2 is the difference in procurement structures distinguishing the Walmart supply network from the La Colonia system: Walmart assumes the transportation costs and risks of sourcing the crop in the field while La Colonia does not. Walmart sends its trucks to the farmers’ community to source produce while La Colonia suppliers make the trip to the supermarket’s Managua headquarters themselves.

Sourcing at the farmgate may offer Walmart a special advantage in price negotiation in a market in which farmers face high transport and transactions costs. In Table 3, we compare per kg mean prices farmers reported receiving at farmgate from traditional wholesalers with prices (less transport) in the Managua market. Surveyed farmers were asked maximum, minimum, and most common price observed for their most remunerative crop. Given these data, we can use a triangle distribution to infer the mean of the regional farmgate price paid by field brokers. For comparison, we include corresponding Walmart, La Colonia, and Managua mean per kg farmgate prices.

The comparison between farmgate prices in Table 3 suggests significant margins may separate the prices farmers report receiving from traditional wholesalers at the farmgate and documented farmgate prices (price less transport) in the Managua market. Such margins might result from a lack of public or private transport to take crops to market, credit to finance transport, or coordination

<table>
<thead>
<tr>
<th>Crop</th>
<th>Dates (mm/yy)</th>
<th>(SC/kg) Traditional</th>
<th>(SC/kg) Walmart</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sébaco co-op</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roma tomatoes Observations</td>
<td>04/05–11/06</td>
<td>5.23</td>
<td>3.40</td>
<td>&lt;10⁻⁴</td>
</tr>
<tr>
<td>Salad tomatoes Observations</td>
<td>04/05–11/06</td>
<td>91</td>
<td>94</td>
<td>&lt;10⁻⁴</td>
</tr>
<tr>
<td><strong>Ocotal co-op</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roma tomatoes Observations</td>
<td>06/05–05/08</td>
<td>6.33</td>
<td>4.24</td>
<td>&lt;10⁻⁴</td>
</tr>
<tr>
<td>Salad Tomatoes Observations</td>
<td>06/05–05/08</td>
<td>78</td>
<td>234</td>
<td>&lt;10⁻⁴</td>
</tr>
<tr>
<td><strong>La Colonia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sebaco co-op Roma tomatoes Observations</td>
<td>04/06–12/07</td>
<td>6.40</td>
<td>6.30</td>
<td>p = 0.77</td>
</tr>
<tr>
<td>Salad tomatoes Observations</td>
<td>04/06–12/07</td>
<td>89</td>
<td>119</td>
<td>&lt;10⁻⁴</td>
</tr>
<tr>
<td>Ocotal co-op Roma tomatoes Observations</td>
<td>06/06–10/07</td>
<td>7.94</td>
<td>5.92</td>
<td>&lt;10⁻⁴</td>
</tr>
<tr>
<td>Salad Tomatoes Observations</td>
<td>06/06–10/07</td>
<td>69</td>
<td>268</td>
<td></td>
</tr>
</tbody>
</table>
failures to bulk produce with other farmers. The assumption that Managua per kg wholesale prices less transport costs should equal farmgate prices is based on a further assumption: that farmers can transport the crop to Managua themselves or that competition among farmgate traders bids away supernumerary profit. A failure in the capital markets for small farmers, however, increases the price of transporting the crop if farmers cannot secure funds to purchase or rent transportation. A second problem could stem from limited competition among farmgate wholesalers in rural output markets; regional wholesaler monopsonies preserve trader marketing margins. Simultaneous failures in these markets, high opportunity costs of farmer time, or coordination failures among farmers leave resource-poor small farmers to accept the low price offered by traders at the farmgate.

Reaching deep into the countryside, Walmart’s supply network facilitates participation by farmers who would otherwise lack the capital to transport produce to the central market in Managua. The company could therefore take advantage of any price margins separating the city from the countryside, negotiating a per kg farmgate price better than what traditional farmgate wholesale buyers offer rural farmers yet still significantly below the Managua price (less transport costs). Of course, it may be that Walmart assumes significant procurement costs and earns no profit on the provision of procurement in farmers’ communities. However, Walmart’s scale and efficiency imply bulk transport costs significantly less than the cooperatives’ transport costs. These are possibilities that we cannot test using our current data.

La Colonia’s transaction proximity to the Managua market explains why the domestic chain’s prices tend to approximate or exceed the per kg farmgate prices estimated from the Managua market prices (Table 2). La Colonia cannot take advantage of the spatial arbitrage opportunity because its suppliers come to Managua to make semi-weekly deliveries. La Colonia suppliers and cooperatives are equipped with trucks; they make habitual stops to sell excess supply at the Managua markets after delivering produce to the supermarket.

(c) Supermarkets stabilize output price

We examine in this section how per kg farmgate price volatility differs across supermarket and traditional channels. Our analysis of whether supermarkets decrease output price volatility relative to the traditional market begins with a comparison of channel variances and coefficients of variation. We then use stochastic dominance tests to more systematically study the producer’s mean-variance tradeoff across traditional and supermarket channels.

Significant price volatility is a serious concern for farm households. When firms profit-maximize, the convexity of the profit function implies that a firm prefers price volatility. But if household production and consumption decisions are nonseparable and the household is income risk averse then the household is also price risk averse. Residual uninsured risk exposure can lead to inefficient production and investment as households routinely undertake costly measures to reduce exposure. A decrease in output price risk can be expected to lead to improved household efficiency in production and investment.

Data from farmer cooperatives and the traditional market support the hypothesis that supermarkets reduce price volatility over the traditional market. Table 4 reports the first and second moments of producer cooperative and traditional market price distributions using the price data analyzed in Table 2. As in the analysis of mean prices across channels, we consider relative price variance by supermarket chain in turn.

(i) Walmart

The first and second moments of the price distributions reported in Table 4 suggest that Walmart’s suppliers negotiate a mean/variance tradeoff: a lower mean per kg farmgate price is paired with less volatile prices for all Walmart crops and both first and second-generation contracts. Initial comparisons across moments of distributions in Table 4 suggest that Walmart systematically dampens the volatility in farmgate prices compared with the traditional channel, but the exchange for this tempering may be a reduction in mean price. Coefficients of variation in the Walmart channel are uniformly lower than the traditional market.

(ii) La Colonia

As we found in the comparison of mean prices across channels (Table 2), La Colonia exhibits trends that are both distinct from Walmart and distinct across crops. For example, the traditional lettuce market offers a more stable, higher mean farmgate price; La Colonia exhibits a higher mean price and lower price variance for salad tomatoes; but cabbage prices are characterized by a higher mean with the supermarket and slightly higher variance.

We can more systematically study the producer’s mean-variance tradeoff across channel-specific price distributions by testing the stochastic dominance of supermarket price distributions against the traditional market farmgate price distribution. Each crop-specific pair of price distributions is characterized by cumulative distribution functions $F_T$ and $F_S$ for the traditional and supermarket channels, respectively. For all monotonically increasing utility functions, distribution
For the stochastic dominance tests, we use all dates for which we have price information for the traditional market. We include prices for all recorded dates for the traditional market under the assumption that the full 2001–08 series better reflects the true inter-temporal distribution of prices in the marketplace. To compare 2001–08 prices with the period of the supply relationship we must assume both that the underlying price-generating process is unchanged and that farmers perceive the 2001–08 distribution as a consistent representation of the distribution of farmgate prices that they face.2

Note that the comparison of prices below using stochastic dominance tests biases the analysis in favor of supermarkets. First, as supermarket chains only accept 70% of farmers’ output, while traditional markets can accept all produce, the supermarket price distribution only affects 70% of farmer output; if we found supermarkets paid higher net prices, those higher prices would only apply to that portion of farmer output. Second, just examining the price distribution does not take into account risks that are inherent (although of different types) in both supermarket and traditional market channels. We focus our examination of those differential risks here. For example, supermarket agreements can increase a farmer’s risk of total loss should the supermarket renege on the sales agreement at the time of harvest through failure to purchase or failure to pay. Supermarkets pay farmers by cash or by check with a delay ranging from a few days to a few weeks. In contrast, spot market payment is generally at the time of sale. Supermarkets do not charge slugging fees for cooperatives’ produce nor is there a formal rebate stated in the contract. Our survey data suggest that the likelihood of loss due to supermarket failure to make payment is significantly higher than the traditional market; the reported annual incidence of supermarket payment default is 1.3%, nearly double the traditional market payment default rate reported in traditional markets. Given that the supermarket represents an increase in both the probability of buyer default and of rejections resulting from standards enforcement, the supermarket per kg revenue distribution will always have a higher mass at zero than the traditional market. Therefore in a dominance test comparing total revenue distributions between those differential market and the supermarket market channel, the distribution of possible total revenue outcomes under the supermarket can never first-order dominate the traditional market.

(iii) La Colonia

Table 5 presents a summary of the results of stochastic dominance tests. Figure 1 plots the cumulative distribution functions for both salad tomatoes and roma tomatoes for La Colonia and the first and second-generation Walmart contracts, illustrating a subset of the first order stochastic dominance tests in Table 5. As expected from results in Tables 2 and 4, the K-S and McFadden tests provide evidence that the La Colonia price CDFs in some cases dominate and in others are dominated by the traditional channel.

(iv) Walmart

As with the mean price comparisons, the sequence of Walmart supply agreements is critical to interpreting the FOSD tests. Results from the McFadden tests in Table 5 and the second row of Figure 1 suggest that traditional market first-order dominates the supermarket for Walmart’s early first-generation contracts for roma tomatoes and salad tomatoes from Sibaco.

In the FOSD joint analysis of the first and the second moment of the price distribution we see evidence of Walmart’s

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Table 4. Per kg farmgate price mean and variance in supermarket and traditional market channels

<table>
<thead>
<tr>
<th>Crop (units)</th>
<th>Mean (SC/kg)</th>
<th>Variance</th>
<th>CV (σ/μ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walmart (WM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WM Sibaco co-op roma tomatoes</td>
<td>3.40</td>
<td>0.66</td>
<td>0.24</td>
</tr>
<tr>
<td>Managua roma tomatoes</td>
<td>5.23</td>
<td>2.68</td>
<td>0.31</td>
</tr>
<tr>
<td>WM Sibaco co-op salad tomatoes</td>
<td>4.41</td>
<td>0.44</td>
<td>0.15</td>
</tr>
<tr>
<td>Managua salad tomatoes</td>
<td>6.68</td>
<td>5.82</td>
<td>0.36</td>
</tr>
<tr>
<td>WM Ocotal co-op roma tomatoes</td>
<td>4.24</td>
<td>1.68</td>
<td>0.31</td>
</tr>
<tr>
<td>Managua roma tomatoes</td>
<td>6.33</td>
<td>7.51</td>
<td>0.43</td>
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<td>WM Ocotal co-op salad tomatoes</td>
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<td>0.64</td>
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<td>6.47</td>
<td>0.34</td>
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<td>0.20</td>
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<td>0.24</td>
</tr>
<tr>
<td>LC lettuce</td>
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<td>2.59</td>
<td>0.33</td>
</tr>
<tr>
<td>Managua lettuce</td>
<td>5.57</td>
<td>1.59</td>
<td>0.23</td>
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contractual evolution with its suppliers. In a departure from the earlier contracts, results from the McFadden tests presented in Table 5 and the bottom row of Figure 1 demonstrate that the second-generation contracts for tomatoes from Ocotal were not strictly dominated by the traditional markets.

The dominated nature of Walmart’s first generation contracts may explain the introduction of the second-generation agreements. Early Walmart supply agreements did not increase mean farmgate prices for the farmer relative to the traditional market—indeed, our data indicate that early contracts were stochastically dominated by the traditional market.

The second-generation of Walmart contracts codified what had previously been an implicit price insurance of the contract. Beginning in 2007, Walmart introduced supply agreements that explicitly provide farmers insurance against price risks of the traditional market. The company also began moving NGO-backed farmers and farmer cooperatives to year-round production agreements featuring seasonal planting plans. In early 2008, farmers described three distinct contract types. All contracts were pegged to a reference traditional market price, an average at the time of sale of the prices in two Managua wholesale markets and a regional market close to the farmer. The three contract types were: an average-price contract in which Walmart pays the average traditional market price; a price-band contract in which Walmart and the farmers fix an upper and lower bound on the average

Figure 1. First order stochastic dominance tests for roma tomato and salad tomato in La Colonia (top row), Walmart first-generation (second row), and Walmart second generation (bottom row). All price CDFs are plotted against corresponding traditional market CDFs.
traditional market price and Walmart pays the farmer the lower bound if the average falls below the lower bound and the upper bound if the average market price exceeds the upper bound; and a price-floor contract (introduced in 2008) in which Walmart and farmers fix a lower bound on the average traditional market price and Walmart pays the average traditional market price less 15% or the floor price.

Walmart and the Ocotal cooperative negotiated a price band contract in 2007. The minimum negotiated price for roma tomatoes was 3.50 CS/kg and the maximum 6.20 CS/kg. The comparison means from the Managua wholesale market during this period was 5.02 CS/kg and the reported mean farmgate price for roma tomatoes 4.43 CS/kg. Salad tomatoes had a negotiated minimum price of 5.52 CS/kg, and maximum at 8.27 CS/kg; the Managua comparison mean for salad tomatoes was 6.34 CS/kg. The 2007 contract also set minimum and maximum prices for sweet bell pepper, small green pepper, jalapeno pepper, cucumber, and baby corn.

Both the price-band contract and the price-floor contract embed an insurance contract; the supermarket eliminates some share of traditional market downside price risk, truncating the lower tail of the traditional market price distribution. Producers pay for the insurance in the form of a reduced mean price. The bottom row of Figure 1 plots the CDFs for Roma and salad tomatoes for the Ocotal cooperative for the tenure of their contract.

A critical question we address in the next section is how much farmers are willing to lower their expected mean price with the supermarket in order to truncate their distribution of possible prices. Do farmers pay too much?

4. ESTIMATES OF RELATIVE RISK AVERSION COEFFICIENTS

We have established that a primary impact of a supply agreement for small farmers is a reduction in price volatility. The contract reduces uninsured risk exposure that can discourage investment and innovation and risk averse households are expected to be willing to pay a premium to reduce risk exposure. Households have heterogeneous risk preferences; in general, poorer households are more risk averse and are willing to pay more than wealthy households to avoid a monetarily equivalent risk. In the context of our analysis, a higher willingness of poor households to pay to avoid price risk could provide another explanation for the willingness of supermarkets to work with small farmers.

Assuming that the farmers are expected utility maximizers, we can determine whether farmers adopting Walmart supply contracts are paying too much for the price risk insurance by using our data to compute the farmers’ minimum relative risk coefficients that rationalize acceptance of the contract. By comparing derived relative risk coefficients with coefficients that have been estimated in the empirical risk literature we can assess the degree of risk aversion implied by preference for the contracts over the wholesale markets. Under the assumptions of the expected utility hypothesis, our finding high relative risk coefficients for farmers means that they are accepting prices that are too low.

Greater risk aversion is associated with a more curved utility function. The coefficient of relative risk aversion, $R$, at income $Y$, is the elasticity of marginal utility at income $Y$. The dimensionless measure is defined as:

$$ R(Y) = -\frac{Y U''(Y)}{U'(Y)}. $$

Newbery and Stiglitz (1981) Taylor series approximation of certainty equivalent income gives an approximate definition of relative risk aversion: individual $i$'s relative risk aversion is equal to income times two times the risk premium divided by the income variance.

$$ R_i(\bar{Y}) = \frac{\bar{Y} 2 \rho_i}{\sigma_i^2}. $$

We assume that the traditional market price $p_i$ is characterized by variance $\sigma_i^2$ and the Walmart supply channel price is characterized by $\sigma_i^2$, with $p_i > p_s$ and $\sigma_i^2 > \sigma_s^2$. The risk premium, $\rho_i$, is equal to farmers’ annual quantity of tomatoes transacted, $Q_i$, times the difference in mean per kg farmgate prices between the traditional and supermarket channels. We use predicted 2007 household income for $\bar{Y}$. The variance $\sigma_i^2$ is the price variance in the higher-mean traditional market, $\text{var}(Q_{ps})$.

Our method of estimating the relative risk coefficient is based only on the variance in the traditional market. We do not include any reference to the income variability in the Walmart supermarket channel. Because we have established that the Walmart channel is characterized by less variance than the traditional market, any correction for the variance of the Walmart channel would only decrease the denominator in Eqn. (2) and increase $R$. Therefore, this assumption effectively sets a lower bound on the derived value of risk aversion, $R_{\text{eqn.2}}$.

$$ R_{\text{eqn.2}}(\bar{Y}) \geq \frac{\bar{Y} 2 Q_i (p_s - p_i)}{Q_i^2 \sigma_i^2} - \frac{\bar{Y} 2 (p_i - p_s)}{Q_i \sigma_s^2}. $$

Eqn. (3) has an intuitive interpretation. The minimum relative risk aversion rationalizing the investment in the supermarket supply chain is increasing in the difference between mean prices and decreasing in the variance of the spot market and the quantity transacted.

We use household survey data from Ocotal cooperative members who sell to Walmart to compute farmer-specific coefficients of relative risk aversion. A second estimate uses farmers who quit supplying supermarkets but continued to grow roma tomatoes.

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**Table 5. Results from the McFadden test of first order stochastic dominance and generalized Lorenz test of second order stochastic dominance comparing supermarket and traditional per kg farmgate CDFs**

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<tr>
<td><strong>La Colonia contracts</strong></td>
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<tr>
<td>La Colonia roma tomatoes (Sébaco)</td>
<td>La Colonia</td>
<td>La Colonia</td>
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<tr>
<td>La Colonia salad tomatoes (Sébaco)</td>
<td>La Colonia</td>
<td>La Colonia</td>
</tr>
<tr>
<td>La Colonia peppers (Tomatoya)</td>
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<tr>
<td>La Colonia cabbage (Tomatoya)</td>
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</tr>
<tr>
<td>La Colonia lettuce (Tomatoya)</td>
<td>No dominance</td>
<td>Spot market</td>
</tr>
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<td><strong>Walmart first-generation contracts</strong></td>
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<td>Walmart roma tomatoes (Sébaco)</td>
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<td>Spot market</td>
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<td>Spot market</td>
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<tr>
<td><strong>Walmart second-generation contracts</strong></td>
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<tr>
<td>Walmart roma tomatoes (Ocotal)</td>
<td>No dominance</td>
<td>No dominance</td>
</tr>
<tr>
<td>Walmart salad tomatoes (Ocotal)</td>
<td>No dominance</td>
<td>No dominance</td>
</tr>
</tbody>
</table>
Table 6 presents computed ranges of coefficients of relative risk aversion for farmers with positive 2007 predicted incomes for current suppliers and farmers who left the supply chain (nonsuppliers). Coefficient means are somewhat high given estimated coefficients generally range between one and three (Chavas & Holt, 1996; Saha, Shumway, & Talpaz, 1994). The distributions of estimated coefficients suggest that some farmers’ adoption of supply agreements implies implausibly large coefficients of relative risk aversion.

An equivalent approach assesses suppliers’ revealed relative risk preferences by fixing $R$ in Eqn. (3) and deriving farmers’ implied willingness to pay for the new distribution. This inversion of the $R$ estimation problem provides a valuable analytical complement; we can use this extension to estimate the maximum per kilo risk premium ($p_r - p_s$), the maximum mean price difference between the traditional and supermarket channels that justifies for the farmer the adoption of the supermarket contract. This per kg risk premium can be thought of as the farmer’s willingness to pay for the insurance against price volatility in the supply contract.

We set $R(\gamma) = 1, 2, 3$—values that have been estimated in the literature using a range of utility functions and specifications (Chavas & Holt, 1996; Saha et al., 1994). Bellemare, Barrett, and Just (2011) adopt a similar approach, pegging relative risk aversions coefficients in estimations of crop cross-price risk aversion coefficients.

The bottom section of Table 6 presents results from the willingness to pay approach, in which we set values of relative risk aversion $R$ and compute farmer-specific limits on the per kg mean price reduction between the traditional and supermarket channel. The true observed per kg difference in mean price between the traditional and supermarket channels is 2.03 C$/kilo. Therefore, a computed maximum willingness to pay less than 2.03 C$/kg suggests that farmers at the assumed level of relative risk aversion should reject the contract, given their risk preferences and the price mean implied by the contract. The third and fifth columns of Table 6 indicate the percent of farmers (suppliers and nonsuppliers) for whom, given the assumed level of risk aversion, the supermarket mean/variance reduction, represents an economically reasonable choice over the traditional market.

Results in the lower half of Table 6 suggest that, over an established range of farmer risk aversion, most current supplier farmers’ willingness to pay for the price insurance is less than the contract’s 2.03 C$/kg mean price reduction. That is, established levels of relative risk aversion cannot explain the adoption levels that we see.

As expected, as assumed coefficients of relative risk aversion increase in Table 6, the terms of the supermarket price distribution (specifically the reduction in mean price given the reduction in price variance) are attractive to a larger share of both current participants and nonsuppliers. Notice, comparing columns three and five, that the terms of the supply contract are relatively more suited to the nonsuppliers—that is, a larger share of nonsuppliers at all levels of assumed relative risk aversion would accept the reduction in mean price for the reduction in volatility it implied. Part of what drives the higher relative suitability of the contract terms to the nonsuppliers is that the derived maximum mean price reduction $p_r - p_s$ is decreasing in income. As a group, the supermarket suppliers have significantly higher incomes than those not supplying supermarkets in Table 6 and thus their maximum acceptable reduction in mean price given an assumed level of risk aversion is lower.

Evidence in Table 6 suggests some farmers pay a high price for price volatility insurance in the Walmart contract. Three possible explanations might account for participant farmers’ apparent high willingness to pay for reductions in price volatility. First, our analysis may be picking up the differences between risk and loss aversion. If farmers are loss averse, with a strong preference to avoid sharp seasonal price drops, they might have a higher value for the insurance of the contract than our analysis can assess. Second, the supermarket contract may offer the farmers an opportunity for portfolio diversification. Our analysis of prices and volatility in a single market may not capture the farmer’s decision problem if he or she optimizes over the total risk of the farm’s marketing portfolio. A third possibility is that farmers perceive the probability of an extremely low price in traditional markets to be significantly higher than reflected in the year-round data collected by the Nicaraguan government. We have shown that farmers adopting supermarket contracts are generally without irrigation at the time of adoption; their experience of horticulture markets prior to the supermarket is seasonal. When farmers adopt supermarket contracts, they are generally moving into year-round production and marketing for the first time.
Producers may base risk assessments on prior marketing experience, likely limited to brief periods of seasonal production characterized by high price volatility. Because traditional seasonal nonirrigated producers of horticultural crops tend to harvest and plant within the same narrow window as one another, they tend to be in the markets when prices are most volatile. If producers remember these market gluts acutely, they may be willing to accept from the supermarket contract a decrease in mean price in order to insure themselves against what is, in fact, a relatively rare event, a price crash in a local or regional market.

If this explanation holds, it would carry implications for the sustainability of Walmart’s contract structures and pricing over time. Farmers will update their beliefs about the underlying price distributions over time, learning the true annual price distribution as they switch to year-round cultivation, and their valuation of the contract may change. Moreover, we find that by 2008, 83.3% of the 54 supplier farmers in this analysis were equipped with some irrigation. Given supermarkets serve as the spur to move to a more intensive production calendar and investment in irrigation, and given that irrigation systems provide farmers with the capacity to ride out seasonal price fluctuations, it is not clear if, once equipped with irrigation, farmers will continue to value the supermarket contract.

5. CONCLUSIONS

Research into the consequences and possibilities of the expansion of supermarket operations in Africa, Asia, and Latin America has centered on establishing the economic and institutional conditions under which supply relationships between small farmers and supermarkets take place and documenting the impacts of the inclusion and exclusion of smallholders. Research has not yet addressed the mean and variance of the net price paid by supermarkets and traditional markets nor examined the variation in price mean and stability over different contract designs. Finally, no work has examined the cost of reduction of risk in reduced mean price. Addressing these questions for the first time, our analysis offers a new perspective on the payoffs to participation in supermarket supply channels for farmers.

We find that La Colonia, Nicaragua’s domestic supermarket chain, offers farmers a market option similar to the traditional market in mean price and price variability. Walmart has pursued a different strategy. To draw in suppliers, Walmart initially employed a pricing method similar to field brokers’ prices. Walmart took advantage of credit and transport failures that led to this spatial market segmentation, offering terms similar to traditional farmgate buyers. Early Walmart supply agreements were not welfare improving for the farmer relative to the traditional market—indeed, they were often stochastically dominated by the traditional market.

Beginning in 2007, Walmart changed its supply agreements to provide farmers insurance against the price risks of the traditional market. Farmers prefer these insurance contracts to the traditional market, and the supply agreements now both provide access to those who did not have market access previously and address the price risk problem in traditional spot markets. However, our analysis suggests that some farmers may be paying too much for this insurance against traditional market price volatility.

Finally, our findings demonstrate that features of the traditional market including spatial segmentation, output price variability, and competition among regional wholesalers affect private contract outcomes. Improved understanding of supply relationships between smallholders and supermarkets can bring new insight into constraints in traditional agricultural markets and contribute to our knowledge of the causes and persistence of rural poverty. It should be noted, however, that Nicaragua’s supermarket sector is still in an early stage and it remains to be seen how contracts will evolve and whether early participants will continue as suppliers.

NOTES

1. MAGFOR collects wholesale and consumer market data weekly in nine of Nicaragua’s primary spot markets. The data are used in the central bank’s calculation of the inflation index. The researchers accompanied the MAGFOR statisticians twice in their Managua collection trips to observe their methods. The statisticians check the price of each good with three to five wholesale and commercial vendors each visit. On their semi-weekly visits the statisticians vary the group of vendors from which they solicit prices and unobtrusively pass as curious customers among the crowd.

2. This rate includes product rejections; La Colonia and Walmart reject produce that does not meet specifications and supplier farmers in our household survey reported per transaction crop rejection rates between 0% and 80% with an average per transaction rejection percent over the 2000–08 period of 5.8%.

3. If we test farmgate prices received by cooperatives from supermarkets against farmgate prices in traditional markets for all dates during 2000–07, and not merely for restricted dates over which the cooperatives sold to supermarkets, we reject the hypothesis that traditional and supermarket means are equal for green peppers (traditional market significantly higher for the full series) and salad tomatoes (La Colonia significantly higher). All other results are consistent whether we use the full or reduced series for the traditional market.

4. These data come from a survey of 920 producer households implemented for this research between February and July 2008. Details available in Michelson (2010).

5. We compare the two price series first over 2004–06 for supermarkets and 2001–08 for traditional markets and then over 2004–06 for both supermarkets and traditional markets. Results of stochastic dominance tests using the 2001–08 traditional market series do not change when we use the 2004–06 series, with one exception. The Walmart Ocotal contract dominates the traditional market for roma tomatoes under the 2004–06 traditional market price series but there is no dominance using the 2001–08 traditional market series.

6. NGOs assist the cooperatives of this analysis with credit, irrigation, and technical assistance. It could be that the value of such subsidies exceeds the loss of direct mean price difference, creating an artificial net profit not visible to our analysis. This is an interesting critical area for further study.

7. Using survey data, measured 2007 income is regressed on the household’s vector of assets, geographic controls, and demographic characteristics to generate predicted income $Y$. Details are available upon request.
REFERENCES


APPENDIX A

Kernel densities of farmers’ reported farmgate minimum, maximum, and mode prices used to calculate mean farmgate price reported in Table 3.

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